INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print), 2222-5234 (Online)
http://www.innspub.net
Vol. 18, No. 2, p. 82-88 2021

RESEARCH PAPER OPEN ACCESS

Efficacy of different insecticides against gram pod borer (*Helicoverpa armigera*) and their safety to the beneficial fauna

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Key words: Chickpea, *H. armigera*, Insecticides, Mortality, Survival.

http://dx.doi.org/10.12692/ijb/18.2.82-88 Article published on February 26, 2021

Abstract

Helicoverpa armigera is a serious pest of Chickpea. This study was conducted to determine the comparative efficacy of eight different insecticides viz; Novaluron 10 EC, Flubendiamide 480 SC, Emmamectin benzoate 1.9 EC, Spinosad 240 SC, Bifenthrin 10 EC, *Bacillus thuringensis* (Bt), Lufenuron 5% EC and Spinetoram 120 SC against the larvae of *H. armigera* and their safety to beneficial insects on chickpea in experimental area of Entomological Research Institute, Faisalabad Pakistan were recorded. After 3 days of insecticidal application, Bifenthrin and Emmamectin benzoate showed highest reduction of the larval population (86.53%, 76.80%), after 7 days of insecticidal application Bt and Lufenuron showed highest mortality percentages (84.97%, 77.33%) and then after 14 days with the application of Bt and Lufenuron (76.47%, 68.33%) mortality percentages were recorded. After 3 days, Lufenuron and Spinetoram gives highest population survival of the beneficial insects as compared to other insecticides. After 7 days, Bt and Spinetoram while after 14 days the highest survival percentages were recorded in Bt and Lufenuron. Considering the results of the experiment *Bacillus thuringensis,* Bifenthrin and Lufenuron found to be the most effective insecticide while Novaluron and Flubendiamide were least effective insecticides for the control of *H. armigera*.

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Introduction

Among the various grain leguminous crops, chickpea is the most important crop in Pakistan. Chickpea (*Cicer arietinum* L.) belongs to family "Leguminosae", subfamily "Papilonidae" having diploid number of chromosomes 2n=16 is an important pulse crop. In different countries, it is named as gram, chickpea, Chana, Hommos, Vetch, khicher, Garbanzo etc. Summerfield and Roberts (1985) enumerated that Chickpea is probably originated from South Eastern Turkey near Syria and then other countries of the world including Pakistan. Chickpea is mostly grown in sandy areas and semi-arid zones of Pakistan. In Pakistan, chickpea is grown in rainfed area accounts for 88% of the total chickpea area, rice-based system constituting 11% and irrigated system contributes only 1% (Atwal and Dhaliwal, 1997). There are two types of chickpea based upon seed size, color and shape known as Desi and Kabuli. Desi type contributes about 85% of world annual chickpea production while kabuli type contributes 15%. According to a survey in Pakistan, 90% chickpea grown is of desi type. It is also a good source of diet for humans due to its higher fat content, better fiber and protein digestibility. Sexana (1990) reported that it can be used as fodder for livestock because of its high forage value. Gram is a cheap source of protein, it can be used as green grain, dry seed, split cotyledon and also as flour. Nutritionally, it contains 24% protein, 59.6% carbohydrate and 3.2% minerals (Sarwar *et al.,* 2011). During and after flowering, it has the ability to fix nitrogen and can also tolerate higher temperatures (Kharkwal *et al.*, 1988). It plays an important role in increasing soil fertility as nitrogen fixing bacteria present in its roots that can fix 140 kg nitrogen per ha (Rupela, 1987).

Many factors are responsible for its poor yield, but the most important limiting factor on this crop is the occurrence of different insect pest's population (Sarwar *et al.,* 2011). After India, Damage caused by the pod borer is the main to the worldwide production. Among all the insect pests, *H. armigera* is one of the most destructive pest of chickpea. *H. armigera* constitutes a worldwide pest of great economic importance on this crop. It also causes damage to Cotton, Sorghum, Pea, Chilies, Groundnut, Tobacco, Okra, Maize, Tomato and Soybean etc.

It is a polyphagous species and is also an important pest of pulses. The caterpillar feeds on tender, foliage and young pods by making holes in the host and eat the developing seeds by inserting the half portion of their body inside the pod. As a result, holes on pods, absence of seeds on pods and defoliation in early stages are the symptoms of the attack. Before pod formation, the larvae feed on the leaves and tender twigs of chickpea plants. After pod formation, the larvae bore into the pods, feed inside of the seed and cause considerable loss to the seed yield. The population of *H. armigera* increased greatly during the pod formation stage caused substantial damage to pods therefore at this stage control measures become necessary (Deka *et al.,* 1987; Lal, 1996; Patel and Koshiya, 1999).

The moths begin ovipositing on chickpea at the seedling stage but this behavior is checked by the adverse climatic and geographical conditions observed by (Tahhan *et al.*, 1982; Lal, 1996). Soon after hatching, *H. armigera* starts devouring the young shoots, leaves and the pods. Anonymous (2014), Chickpea yield in Pakistan is very low as compared to other countries of the world. Due to unfavorable weather conditions, the largest Rabi crop in Pakistan during 2013-2014 having an estimated consumption of 200 thousand tons witnessed the production of 475 thousand tons against the production of 751 thousand tons of last year showing the decline of 36 percent. *H. armigera* is a major pest of gram that causing 37-50% loss to gram crop.

This is because of biotic and abiotic factors. In biotic factor among insect pests, *H. armigera* (Noctuidae; Lepidoptera) is an important pest of gram (Atwal and Dhaliwal, 1997).The main objective of the study is to find out the effective Insecticides for the control of *H. armigera* and their safety to the beneficial insects, so that practical recommendations could be made on the basis of relative toxicity of spray.

Materials and methods

Insect Model

In the current procedure, *H. armigera* and Bio-control agents (Lady-bird beetle, Green lacewing, syrphid fly, Spotted Beetle, Black Ants etc) are used to determine the concerned parameters. The experimental procedure was totally field based by following local environmental conditions.

Equipment

The insecticides were applied with the help of "Solo Knapsack Hand Sprayer".

Experimental Area

The present study was carried out to determine the efficacy of different new insecticides against the larval population density of *H. armigera* on chickpea crop in the research area of Entomological Research Institute, Ayub Agriculture Research Institute Faisalabad during Rabi season 2019.

Experimental layout

The experiment was laid out in a Randomized Complete Block Design with 9 treatments including the check. Experiment was repeated thrice. The plot size was 2 X 27 ft^2 and row to row distance was 45 cm. Eight insecticides viz., Novaluron 10 EC (Uniron), Flubendiamide 480 SC (Belt), Emmamectin benzoate 1.9 EC (Proclaim), Spinosad 240 SC (Tracer), Bifenthrin 10 EC (Talstar), *Bacillus thuringensis* (Bt), Lufenuron 5% EC (Match) and Spinetoram 120 SC (Radiant) @ of 300ml, 50ml, 200ml, 40ml, 250ml, 250gm, 200ml and 60ml per acre, respectively were tested for the effective control of *H. armigera*. One pre-treatment and three post-treatment observations were made. The pre-treatment observation was recorded before 24 hours of insecticide application. 3 post-treatment observations were recorded after 3 days, 7 days and after 14 days of insecticide application. For the purpose of data collection, number of pod borer larvae were recorded per plant from each plot.

Formula for calculating damage infestation

Damage Infestation= No of Damaged Pods / Total No of Pod *100.

Statistical analysis

All the experimental data was analyzed by using statistix 8.1 software. One-way analysis of variance (ANOVA) was applied, followed by LSD to differentiate the differences among treatment groups. Only those data were considered statistically significant whose $p<0.05$.

Results

The results from the present study revealed that after insecticidal applications, all the treated plots gave significantly the best results for insect pest suppression than the untreated plots. Interestingly, the beneficial effects of all tested insecticides were noted on plant stand.

Table 1. List of insecticides used in the study.

Common name	Trade name	Formulation	Dose/Acre	Chemical-Family (Group)	Company Name
Novaluron	Uniron	10 EC	300 ml	Benzoylureas	Bayer Crop Sciences
Flubendiamide	Belt	480 SC	50 ml	Flubendiamide	Bayer Crop Sciences
Emamectine Benzoate	Proclaim	1.9 EC	200ml	Avermectins, Milbemycins	Sygenta Pakistan Ltd.
Spinosad	Tracer	240 SC	40 ml	Spinosyns	Arysta Life sciences
Bifenthrin	Talstar	10 EC	250ml	Pyrethroids	FMC
Baccilus thurigensis	Pirate	10 EC	250gm	IGR	Bayer Crop Sciences
Lufenuron	Match	5 % EC	200 ml	Benzoylureas	Sygenta Pakistan Ltd.
Spinetoram	Radiant	120 SC	60 ml	Spinosyn	Arysta Life sciences

Detailed Results and discussion of the experiment "Efficacy of new chemistry insecticides against Gram Pod borer and their safety to the bio-control agents" are given below:

Pre-treatment

Before the application of insecticides, counted the beneficial insects per m/row ranged from 2.13-2.80 and *H. armigera* population among treatments found to be non-significant and has been ranged from 4.36-8.03 larvae per m/row. However, the pre-treatment results revealed that the pest population was above ETL in all plots so the treatments can be applied**.**

Post treatments

First Spray

The data presented in Table 2. showed that all the insecticidal treatments were significantly reduced the larval population of *H. armigera* as compared to the check. After 3 days of insecticidal application maximum reduction of the *H. armigera* larvae (86.53%) was recorded in Bifenthrin followed by Novaluron, Flubendiamide, Emmamectin Benzoate, Spinosad, Bt, Lufenuron and Spinetoram that showed mortality percentages (59.63%, 67.67%, 76.80%, 66.67%, 43.77%, 59.67% and 70.0%). After 3 days of insecticidal application maximum survival percentages of the beneficial fauna (59.31%) was recorded in Lufenuron followed by Novaluron,

Flubendiamide, Emmamectin Benzoate, Spinosad, Bifenthrin, *Bacillus thuringensis* and Spinetoram in which observed survival percentages (40.60%, 37.87%, 42.92%, 43.83%, 44.47%, 41.73%, and 50.98%) were recorded.

Table 2. Efficacy of different insecticides against gram pod borer and Survival % of beneficial fauna.

Insecticides	Pre-treatment Data		Mortality %			Survival %		
	GPD	BI	3 DAA	7 DAA	14 DAA	3 DAA	7 DAA	14DAA
Novaluron	8.03 a	2.64 ab	59.63 d	44.43 f	40.23 f	40.60 d	48.14 c	60.33 c
Flubendiamide	7.40 ab	2.13 c	67.67 c	50.33e	42.57 ef	37.87 d	45.41 c	65.33 c
Emamectine Benzoate	5.4333cd	2.80 a	76.80 b	53.33e	55.70cd	42.92 cd	48.90 c	64.79 c
Spinosad	4.36 d	2.60 ab	66.67 c	54.20e	49.10de	43.83 cd	50.40 c	65.33 c
Bifenthrin	4.37 d	2.60 ab	86.53 a	71.47c	61.23 c	44.47 cd	48.23 c	58.21 c
Baccilus thurigensis	6.40 abc	2.20 bc	43.77 e	84.97a	76.47 a	41.73 d	64.79 b	87.33b
Lufenuron	7.70 a	2.60 ab	59.67 d	77.33b	68.33 b	59.31 b	45.50 c	83.67b
Spinetoram	5.59 bcd	2.267 bc	70.00 c	59.67d	49.10de	50.98 bc	50.40 c	68.67 c
Check	7.33 ab	2.13 c	0.0 f	0.00 g	0.00 g	100 a	100.0 a	100.0a
S.Em ±	17.41	0.44	2.59	2.35	3.13	4.08	4.27	5.43
LSD (0.05)	0.89	0.21	6.27	4.982	6.641	8.65	9.04	11.51
CV	1.89	10.6	6.15	5.32	7.8	9.75	9.38	9.16

GPD: Gram pod borer population per m/row

BI: Beneficial insects/plant (Lady-bird beetle, Green lacewing, syrphid fly etc)

DAA: Days after application

Means in the same column showing similar alphabets are at par.

Second Spray

After 7 days of insecticidal application maximum reduction in the larval population of *H. armigera* (84.97%) was recorded in *Bacillus thuringensis* followed by Novaluron, Flubendiamide, Emmamectin Benzoate, Spinosad, Bifenthrin, Lufenuron and Spinetoram in which observed mortality percentages were 44.43%, 50.33%, 53.33%, 54.20%, 71.47%, 77.33% and 59.67%. After 7 Days of insecticidal application maximum survival percentage (64.79%) was recorded in *Bacillus thuringensis* followed by Novaluron, Flubendiamide, Emmamectin Benzoate, Spinosad, Bifenthrin, Lufenuron and Spinetoram in which observed survival percentages (48.14%, 45.41%, 48.90%, 50.40%, 48.23%, 45.50% and 50.40%) were recorded.

Third Spray

The data presented in Table 2. revealed that the larval population of *H. armigera* were significantly reduced by the application of insecticides as compared to the check plot. After 14 days of insecticidal application, mortality percentage (76.47%) of *H. armigera* was highest recorded in *Bacillus thuringensis* followed by Novaluron, Flubendiamide, Emmamectin Benzoate, Spinosad, Bifenthrin, Lufenuron and Spinetoram in which observed mortality percentages were 40.23%, 42.57%, 55.70%, 49.10%, 61.23%, 76.47%, 68.33% and 49.10%. After 14 Days of insecticidal application maximum survival percentage (87.33%) was recorded in *Bacillus thuringensis* followed by Novaluron, Flubendiamide, Emmamectin Benzoate, Spinosad, Bifenthrin, Lufenuron and Spinetoram in which observed survival percentages (60.33%, 65.33%, 64.79%, 65.33%, 58.21%, 83.67% and 68.67%) were recorded. However, there was no significant difference among the treatments. The data revealed that among all the insecticides used in this experiment *Bacillus thuringensis,* Bifenthrin and Lufenuron found to be the most effective insecticide for the control of *H. armigera* population and also proved eco-friendly for the other beneficial insects.

Discussion

In the recent experiments, cypermethrin was proved to be the most effective insecticide in accordance with (Gohokar *et al.*, 1985; Singh *et al.,* 1987; Khan *et al.,* 1993; Jadhav and Suryawanshi, 1998). Endosulfan was found to be the more effective insecticide in the experiments of (Chaudary *et al.*, 1980; Rizvi *et al.*, 1986). Because of frequently used insecticides, this pest has now gained the resistance against insecticides. Phokela *et al.* (1990) stated that the population of *H. armigera* gained resistance in response of Cypermethrin. Ahmad *et al.* (1995) also stated that due to the application of Cypermethrin on the field population of *H. armigera*, high level of resistance was recorded while due to the application of Endosulphan moderate resistance was aslo recorded. At the stage of pod formation, the larval population of *H. armigera* becomes higher observed by (Deka *et al.,* 1987; Lal, 1996; Patel and Koshiya, 1999), as a result severe damage to the pods also becomes higher. Therefore, at this stage it is essential to apply the control measuers. Sharma and Chawla (1992) revealed that insecticides should be applied according to the recommendations of the manufacturer (the purpose is to preserve the insecticides) and further explained that all insecticides have its own efficacy not only to control the larval population of *H. armigera* but to the control of other pests also. Such experiments had also been performed by (Mubeen *et al.,* 2014; Sahito *et al.,* 2012; Rashid *et al.,* 2003; Khan *et al.,* 1999). The experiments performed by Rashid *et al.* (2003) shown that Spinosad and Indoxacarb were highly effective against *H. armigera* while Endosulfan was found to be the least effective insecticide. Endosulfan was found to be more effective, though their results cannot be compared with the present study results due to the difference in insecticide treatments or due to the other environmental conditions (Khan *et al.*, 1999).

Conclusion

On the basis of present study, we concluded that among all the insecticides, *Bacillus thuringensis,* Bifenthrin and Lufenuron were found to be the most effective insecticide while Novaluron and Flubendiamide are least effective insecticides for the control of *H. armigera*.

Acknowledgement

I would like to pay thanks to the Government of Jilin Province for funding under the Jilin Government Fund on ACB Control (20150101073JC) and under the Ministry of Science and Technology of China (2017YFD0201804-5). The authors enhance their contribution to University of Agriculture Faisalabad, Pakistan and very thankful to respected Prof. Chen Ri-Zhao of College of Plant Protection, Jilin Agricultural University, Changchun 130118, PR China, for his kind supervision and support.

Author's Contribution

Arzlan Abbas, Aqsa Abbas and Chen Ri-Zhao conceived and designed research. Muhammad Usman conducted the experiment. Fatima Arshad, Muhammad Awais Arshad and Arzlan Abbas analyzed Data. Arzlan Abbas, Muhammad Ali and Asim Iqbal wrote the manuscript. Asim Iqbal, Wangying and Chen Ri-Zhao helped in editing manuscript language.

Conflict of Interest

The authors declare no any conflict of interest.

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